

Response Under 37 CFR 1.116
Expedited Procedure
Examining Group 2800
Application. No. 10/730,162
Response dated January 18, 2007
Reply to Final Office Action of November 2, 2006
Attorney Docket No. 4444-032065

REMARKS

The Office Action of November 2, 2006 has been reviewed and the Examiner's comments carefully considered. Claims 1-20 are pending in this application, and claims 1, 14, 15 and 17 are in independent form.

The Examiner is thanked for withdrawing the rejections formulated in the previous Office Action. In the present Action, the Examiner has again rejected all of pending claims 1-20. Specifically, claim 1 stands rejected under 35 U.S.C. § 102(b) as being anticipated by Patent Abstracts of Japan, Publication No. 64-067099, published March 13, 1989 and entitled "Diaphragm for Acoustic Equipment" (hereinafter "the '099 publication"). Claim 17 stands rejected under 35 U.S.C. § 103(a) as being obvious over the '099 publication in view of the previously-cited Ward patent and the previously-cited Kanada publication. Claims 1, 2, 4, 6-8 and 14 stand rejected under 35 U.S.C. § 103(a) as being obvious over the '099 publication in view of the Ward patent and the previously-cited Watanabe publication. Claims 9-12, 15 and 16 stand rejected under 35 U.S.C. § 103(a) as being obvious over the '099 publication, the Ward patent, the Watanabe publication, and in further view of the Kanada publication. Claims 3 and 18-20 stand rejected under 35 U.S.C. § 103(a) as being obvious over the '099 publication, the Ward patent, the Kanada publication, and in further view of the previously-cited Yamaji patent. Further, claim 13 stands rejected under 35 U.S.C. § 103(a) as being obvious over the '099 publication in view of European Patent No. 0508596 to Thomas. Finally, claim 5 stands rejected under 35 U.S.C. § 103(a) as being obvious over the '099 publication in view of the Ward patent and the Watanabe publication, and in further view of the previously-cited Inoue and Ogura patents.

In view of the following remarks, Applicants respectfully request reconsideration of these rejections.

Summary of the Invention

As set forth in independent claim 1 of the present application, the invention is directed to a loudspeaker diaphragm. This loudspeaker diaphragm includes a base layer having a woven fabric. Further, this woven fabric is polyethylene naphthalate fiber impregnated with a thermosetting resin.

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Independent claim 14 of the present application is directed to a loudspeaker. This loudspeaker includes a loudspeaker diaphragm, and the diaphragm has a base layer. The base layer is formed from a woven fabric of polyethylene naphthalate fiber impregnated with a thermosetting resin.

Independent claim 15 of the present application is directed to a method for manufacturing a loudspeaker diaphragm. This method includes the steps of: impregnating a woven fabric of a polyethylene naphthalate fiber with a thermosetting resin and curing the thermosetting resin, so as to form a base layer; adding inactive gas in a supercritical state to a molten thermoplastic resin and extruding the mixture of the thermoplastic resin and the inactive gas at prescribed temperature and pressure, so as to form a thermoplastic resin layer; and laminating the base layer and the thermoplastic resin layer. In this manner, the claimed method leads to the manufacture of a unique loudspeaker diaphragm.

As set forth in independent claim 17 of the present application, the present invention is further directed to a loudspeaker diaphragm. This loudspeaker diaphragm includes a base layer as the outermost layer, as well as a thermoplastic resin layer and a thermoplastic elastomer layer. The base layer includes a woven fabric of polyethylene naphthalate fiber impregnated with a thermosetting resin.

As set forth in all of the above independent claims, the present invention is directed to a loudspeaker diaphragm. This diaphragm includes a base layer formed from a woven fabric of a polyethylene naphthalate (PEN) fiber, which is impregnated with a thermosetting resin. A loudspeaker diaphragm formed from such PEN fiber impregnated with a thermosetting resin yields an excellent balance between a Young's modulus and an internal loss. Therefore, the use of PEN fiber impregnated with thermosetting resin provides a unique and effective loudspeaker diaphragm.

Since the base layer is formed from a woven fabric, the respective fibers constituting the base layer easily slip when a diaphragm is vibrated. As a result, vibration energy is converted into heat energy, such that internal loss becomes large. Further, since the PEN woven fabric used in the present invention has an extremely large weave density, there exists a small amount of thermosetting resin as a binder resin between fibers constituting the woven fabric in the resultant diaphragm. As a result, a laminated structure having a woven

fabric layer and a resin layer is substantially formed in the base layer, and such a structure contributes to further improvement of an internal loss.

Still further, due to the extremely large weave density of the PEN woven fabric, a Young's modulus can be satisfactorily maintained. Accordingly, a loudspeaker diaphragm simultaneously satisfying excellent Young's modulus internal loss, which could not be obtained by the prior art, is realized through the claimed invention. Still further, due to slip of the respective PEN fibers, an extraordinarily improved internal loss can be realized compared to a film diaphragm. For example, and as detailed in the present specification (*see* Example 1), a loudspeaker diaphragm manufactured according to the claims of the present application has an internal loss of more than ten times as much as that of various prior art PEN film diaphragms, e.g., the diaphragm described in JP 06-181598 A. Specifically, as seen in Example 1 of the present application, the internal loss of the present invention is 0.45, while an internal loss of the PEN film diaphragm is 0.038.

The Cited Prior Art

All of the Ward patent, Kanada publication, Watanabe publication, Yamaji patent, EP '596, Inoue patent and Ogura patent have been cited throughout the prosecution history of the present application. In addition, and in the present Office Action, these references are used as secondary and/or supportive references to the newly-cited '099 publication. First, Applicants respectfully note that the '099 publication is well known to Applicants and was addressed on page 3 of the originally-filed specification in the "Description of the Related Art" section.

The Examiner has used the '099 publication as the primary reference and basis of all of the rejections in the outstanding Action. In particular, the Examiner refers to the '099 publication in its Abstract form. Therefore, for the Examiner's convenience, and in order to more clearly demonstrate the differences between the present invention and the diaphragm of the '099 publication, a fully translated copy of this Japanese application is provided herewith. In general, the '099 publication describes a diaphragm for acoustic equipment, which diaphragm is formed or molded by a polyester film comprising naphthalenedicarboxylic acid and ethylene glycol. Importantly, the '099 publication

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describes a diaphragm for a loudspeaker having a very small diameter, which is commonly referred to as a “microspeaker”. As seen in the PROBLEMS TO BE SOLVED BY THE INVENTION section of the ‘099 publication, the diaphragm discussed and claimed in this reference is specifically for use in connection with small-diameter (or “micro”) speakers. All throughout this section of the ‘099 publication, the applicant discusses the problems associated with the modulus of elasticity and internal loss with respect to such microspeakers. In order to solve these problems, the diaphragm of the ‘099 publication is a molded product of polyester film comprising naphthalenedicarboxylic acid and ethylene glycol.

As discussed above, the diaphragm of the ‘099 publication is a “film” diaphragm. Therefore, the ‘099 publication is directed to a film diaphragm for use in connection with a microspeaker. The film diaphragm of the ‘099 publication, which is formed from the claimed composition, provides certain benefits over the commonly-used polyester films.

As described above, the method of production and resultant film diaphragm of the ‘099 publication is only applicable for and able to be used in connection with a loudspeaker having a very small diameter, or microspeaker. In particular, according to the technique described in the ‘099 publication, it is possible to obtain a diaphragm having sufficient rigidity and internal loss for being used for a microspeaker. Further, as discussed above, the ‘099 publication provides for a small-diameter diaphragm made from a PEN film. Again, a film diaphragm is generally used for a microspeaker, such as in mobile devices, games and headphones, because a microspeaker requires low cost and light weight.

The Cited Prior Art Does Not Teach or Suggest a Loudspeaker
Diaphragm Having a Base Layer of Woven Fabric of PEN Fiber

The presently-invented loudspeaker diaphragm is very different from the cited prior art, including the diaphragm of the ‘099 publication. Specifically, the present invention is not only different in application and use, but different and distinguishable in construction and structure. In particular, the loudspeaker diaphragm of the present invention includes a base layer having a woven fabric of a polyethylene naphthalate fiber impregnated with a thermosetting resin.

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First, with respect to the application in use of the presently-invented loudspeaker diaphragm (as compared to the diaphragm of the '099 publication), the present invention is used in the area of large-diameter speakers. Again, the '099 publication is specifically directed to microspeakers. The internal loss of a diaphragm in these microspeakers is extremely insufficient for use in connection with a loudspeaker having a large diameter. In fact, it is impossible for the technique discussed and claimed in the '099 publication to be used to obtain an efficient and operable diaphragm that can be used for a loudspeaker having a large diameter.

Still further and as specifically set forth in the specification and claims of the '099 publication, this reference describes a loudspeaker having a small diameter that uses a PEN film diaphragm. Again, a film diaphragm is typically only useful in connection with microspeakers due to the cost and weight constraints. However, the loudspeaker diaphragm of the present invention uses a PEN woven fabric. In fact, each of the independent claims of the present application specifically recite a "woven fabric of a polyethylene naphthalate fiber", which is subsequently impregnated with a thermosetting resin. There are several important differences between a PEN woven fabric diaphragm and a PEN film diaphragm.

The use of PEN fiber in the form of a woven fabric to create the base layer provides an excellent balance between a Young's modulus and an internal loss. Specifically, if, as in the present invention, a woven fabric is used for the base layer, respective fibers constituting the base layer easily slip when the diaphragm is vibrated. Further, and as discussed above, a laminated structure having a woven fabric layer and a resin layer is formed in the base layer, which contributes to further improvement of an internal loss. Still further, the large weave density of the PEN woven fabric allows for the satisfactory maintenance of the Young's modulus. None of these beneficial effects and unexpected results could be obtained by simply using a PEN film diaphragm. None of the '099 publication, the Ward patent, the Kanada publication, the Watanabe publication, the Yamaji patent, EP '596, the Inoue patent nor the Ogura patent teach or suggest a loudspeaker diaphragm including a base layer having a woven fabric of a polyethylene naphthalate fiber impregnated with a thermosetting resin, as specifically set forth in each of independent claims 1, 14, 15 and 17 of the present application.

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Summary

For the foregoing reasons, independent claim 1 is not anticipated by or rendered obvious over any of the cited prior art, whether used alone or in combination. There is no hint or suggestion in any of the references cited by the Examiner to combine these references in a manner which would render the invention, as claimed, obvious. Reconsideration of the rejection of independent claim 1 is respectfully requested. Claims 2-13 and 20 depend either directly or indirectly from and add further limitations to independent claim 1 and are believed to be allowable for the reasons discussed hereinabove in connection with independent claim 1.

For the above reasons, independent claim 14 is not anticipated by or rendered obvious over the prior art of record, whether used alone or in combination. There is no hint or suggestion in any of the references cited by the Examiner to combine these references in a manner which would render the invention, as claimed, obvious. Reconsideration of the rejection of independent claim 14 is respectfully requested.

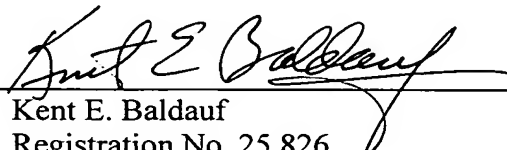
For these reasons, independent claim 15 is not anticipated by or rendered obvious over the cited prior art, whether used alone or in combination. There is no hint or suggestion in any of the references cited by the Examiner to combine these references in a manner which would render the invention, as claimed, obvious. Reconsideration of the rejection of independent claim 15 is respectfully requested. Claim 16 depends directly from and adds further limitations to independent claim 15 and is believed to be allowable for the reasons discussed hereinabove in connection with independent claim 15.

Finally, and for the foregoing reasons, independent claim 17 is not anticipated by or rendered obvious over the prior art of record, whether used alone or in combination. There is no hint or suggestion in any of the references cited by the Examiner to combine these references in a manner which would render the invention, as claimed, obvious. Reconsideration of the rejection of independent claim 17 is respectfully requested. Claims 18 and 19 depend either directly or indirectly from and add further limitations to independent claim 17 and are believed to be allowable for the reasons discussed hereinabove in connection with independent claim 17.

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For all the foregoing reasons, Applicants believe that claims 1-20 are patentable over the cited prior art and in condition for allowance. Reconsideration of the rejections and allowance of all pending claims 1-20 are respectfully requested.

Respectfully submitted,
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